APPENDIX

A Foundation Investigations

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Please note that these conversion tables are approximate. They can be used by characterizing the soil as being either predominately granular or cohesive. If possible, the conversion of the penetration index (N Value) should be checked by performing labatory or in-situ tests.

GRANULAR SOILS

COMPACTNESS	VERY LOOSE		LOOSE		MEDIUM		DENSE		VERY DENSE
Relative Density, D_d		15%		35%		65%		85%	
Standard Penetration Resistance, N = Blows/ft*		4		10		30		50	
Angle of Internal Friction, ϕ		28		30		36		41	
Unit Weight (PCF)									
Moist	100		95-125		110-130		110-140		130+
Submerged	60		55-65		60-70		65-85		75+

VERY LOOSE: A reinforcing rod can be pushed into soil several feet.
DENSE: Difficult to drive a 2x4 stake with a sledge hammer.

* N = Blows/Ft as measured by the standard penetration test (See Appendix B).

$$\text{Relative Density, } D_d = \frac{e_{max} - e}{e_{max} - e_{min}} \times 100$$

e = existing void ratio of mass being considered.
e_{max} = void ratio of same mass in its loosest state.
e_{min} = void ratio of same mass in its most compact state.

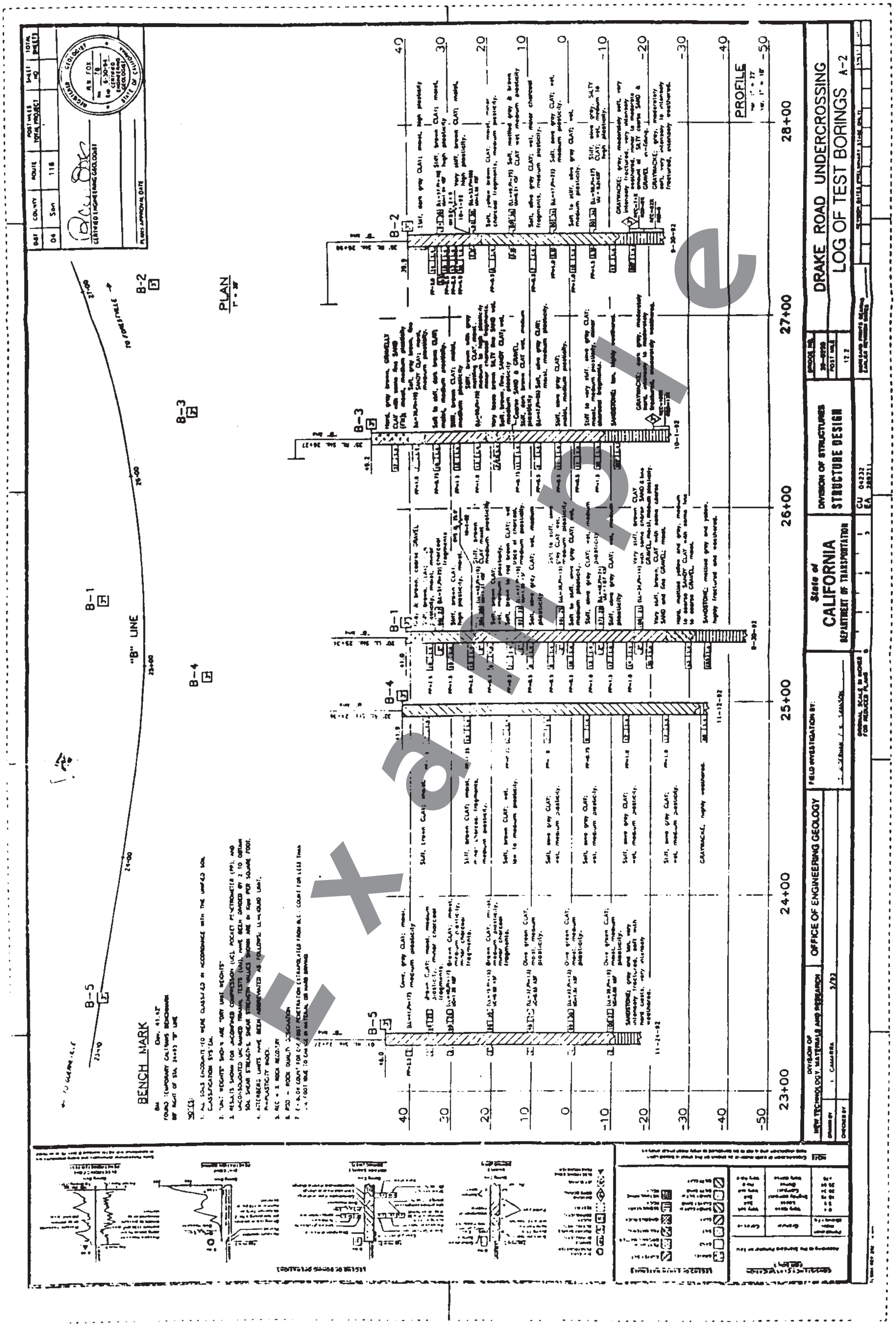
COHESIVE SOILS

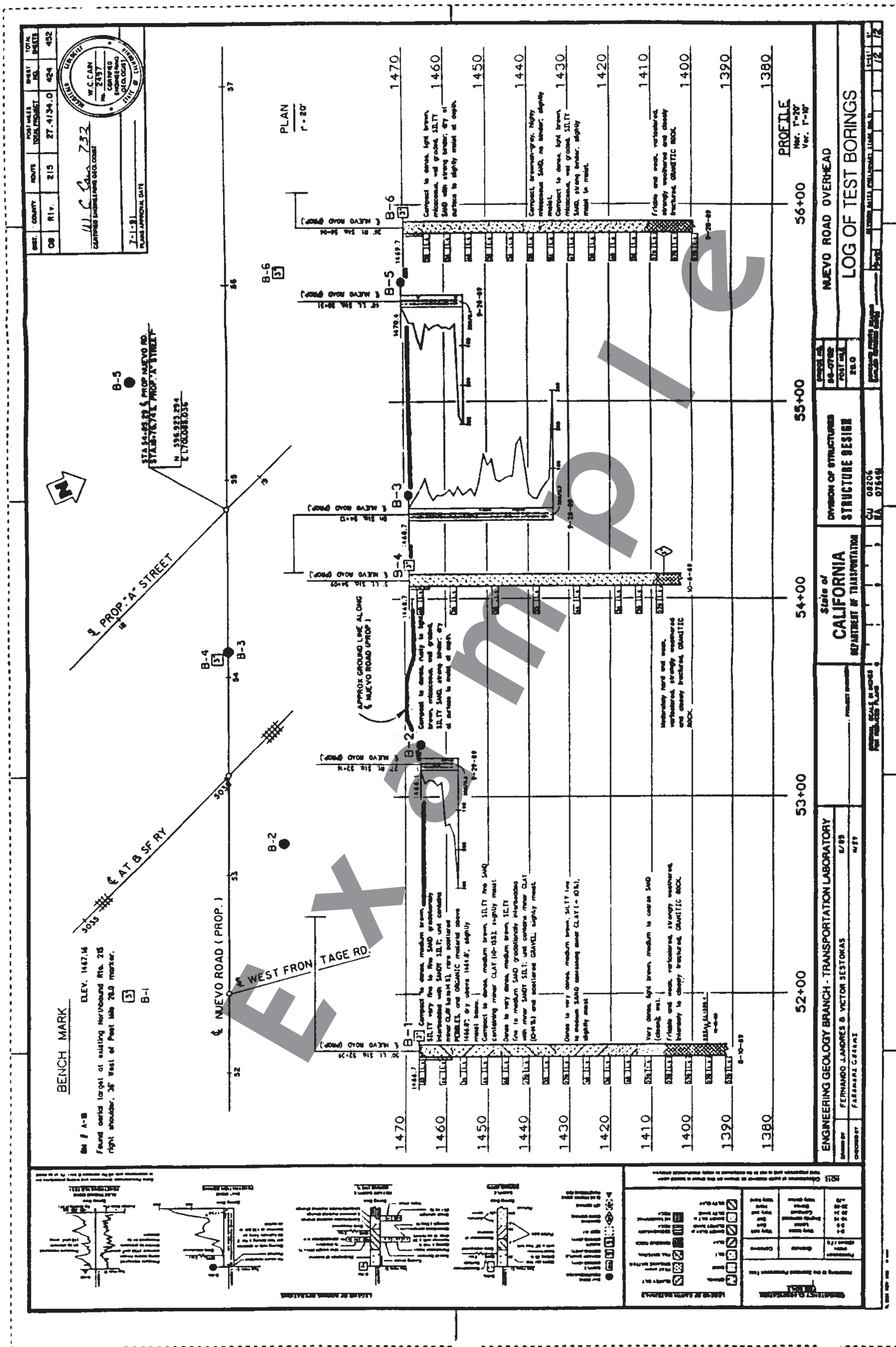
CONSISTENCY	VERY SOFT		SOFT		MEDIUM		STIFF		VERY STIFF		HARD
q_u = unconfined comp. strength (PSF)		500		1000		2000		4000		8000	
Standard Penetration Resistance, N = Blows/Ft *		2		4		8		16		32	
Unit Weight (PCF) Saturated		100-120			110-130			120-140			130+

VERY SOFT: Exudes from between fingers when squeezed in hand.
SOFT: Molded by light finger pressure.
MEDIUM: Molded by strong finger pressure.
STIFF: Indent by thumb.
VERY STIFF: Indent by thumb nail.
HARD: Difficult to indent by thumb nail.

* N = Blows/Ft as measured by the standard penetration test (See Appendix B).

To be used only as a rough guide.


DRAKE ROAD UNDERCROSSING
LOG OF TEST BORINGS
A-2
PROFILE
PLAN
BENCH MARK
"B" LINE
B-1
B-2
B-3
B-4
B-5
State of CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES
STRUCTURE DESIGN
OFFICE OF ENGINEERING GEOLOGY
23+00
24+00
25+00
26+00
27+00
28+00
Example



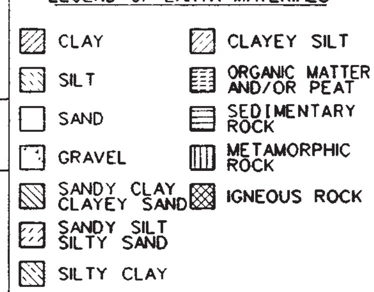
Example
LOG OF TEST BORINGS
NUEVO ROAD OVERHEAD
PROFILE
PLAN
BENCH MARK
℄ PROP. "A" STREET
℄ AT & SF RY
℄ NUEVO ROAD (PROP.)
℄ WEST FRONTAGE RD.
B-1
B-2
B-3
B-4
B-5
B-6
52+00
53+00
54+00
55+00
56+00
1470
1460
1450
1440
1430
1420
1410
1400
1390
1380
ENGINEERING GEOLOGY BRANCH - TRANSPORTATION LABORATORY
State of CALIFORNIA DEPARTMENT OF TRANSPORTATION
DIVISION OF STRUCTURES
STRUCTURE DESIGN

CONSISTENCY CLASSIFICATION FOR SOILS

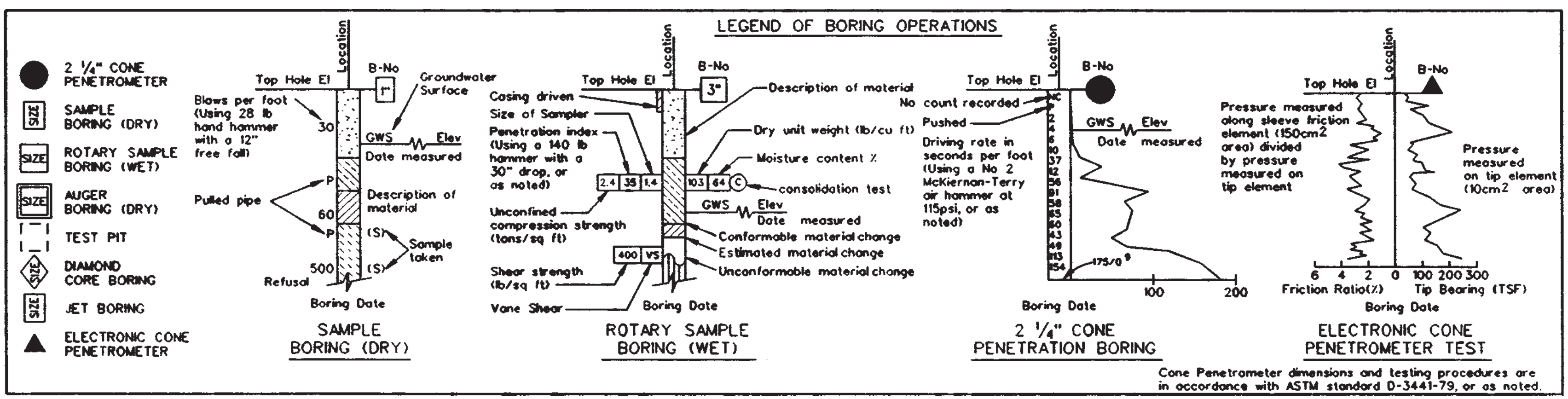
According to the Standard Penetration test

Penetration index (Blows/Ft)	Granular	Cohesive
0-4	Very loose	Very Soft
5-9	Loose	Soft
10-19	Slightly compact	Stiff
20-34	Compact	Very stiff
35-69	Dense	Hard
>70	Very dense	Very hard

LEGEND OF EARTH MATERIALS



NOTE:
Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis



CONSISTENCY CLASSIFICATION FOR SOILS

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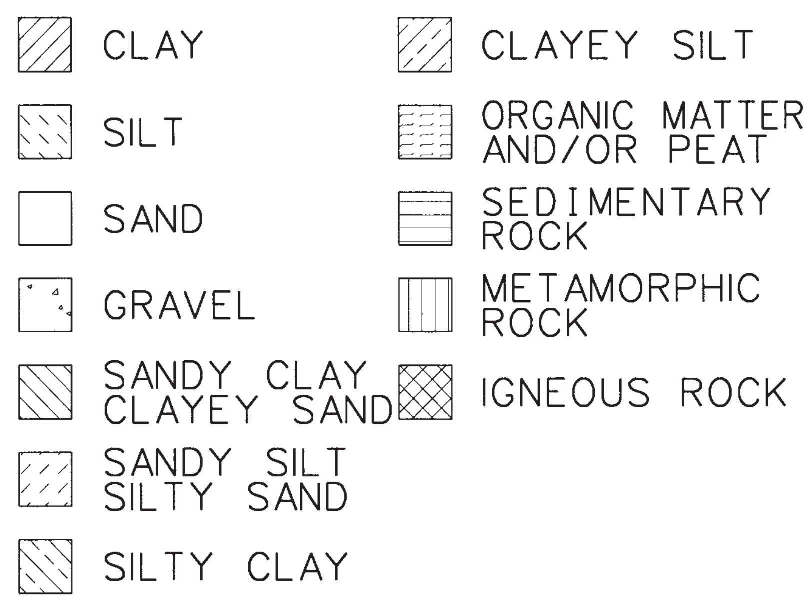
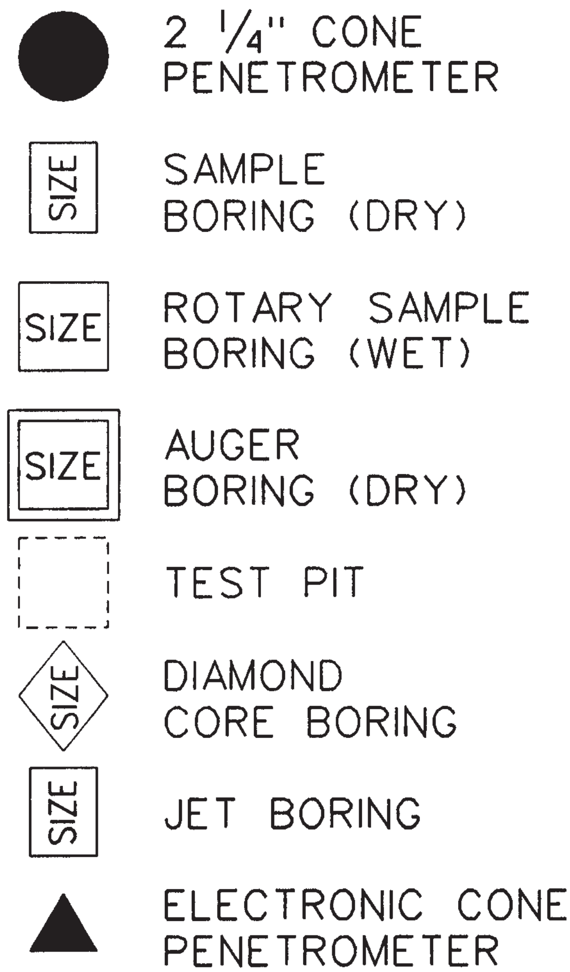
20-34	Compact	Very stiff
35-69	Dense	Hard
>70	Very dense	Very hard

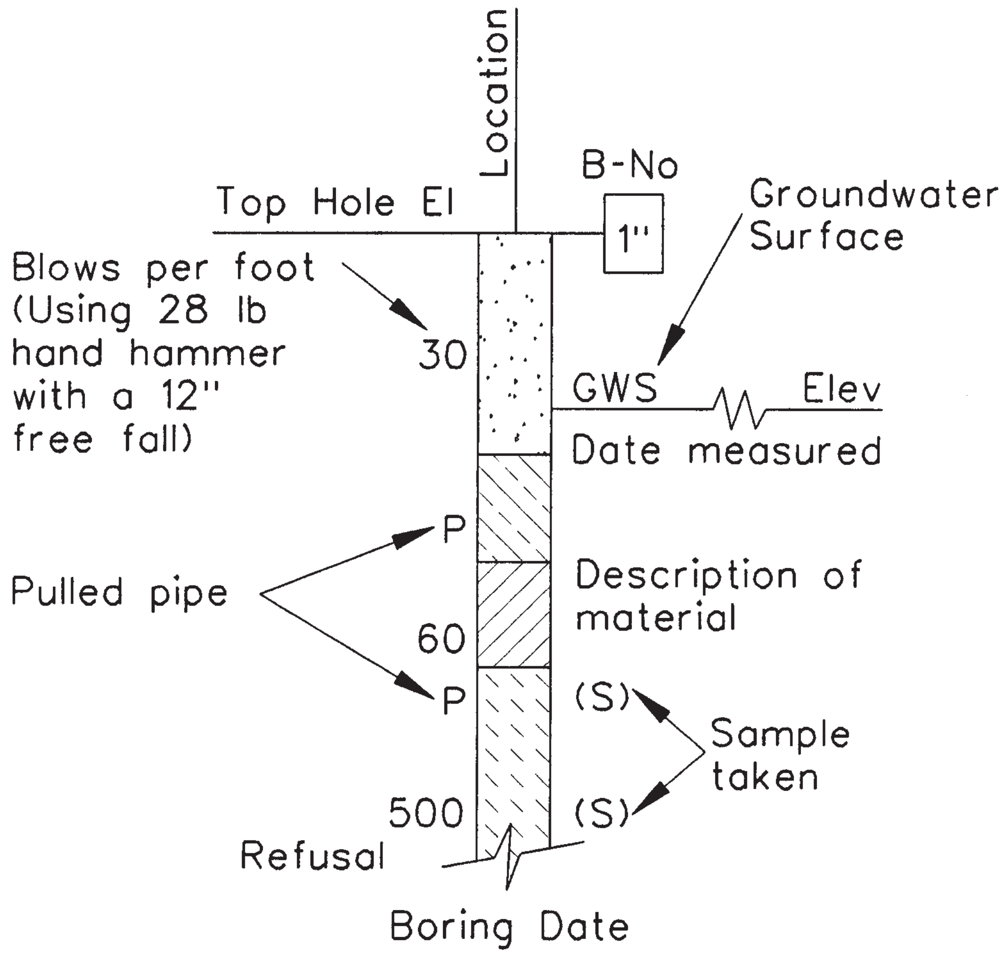
LEGEND OF EARTH MATERIALS



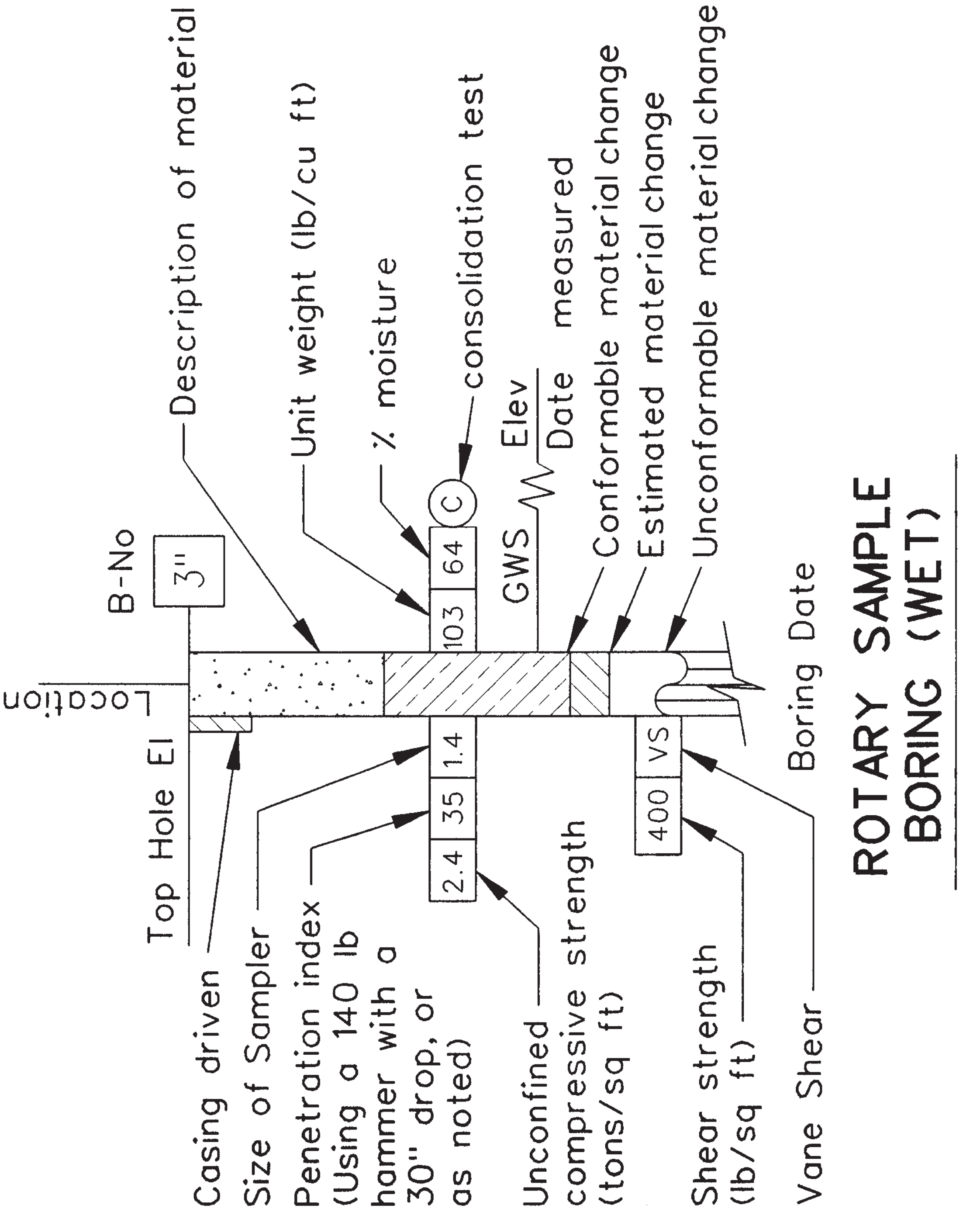
NOTE:

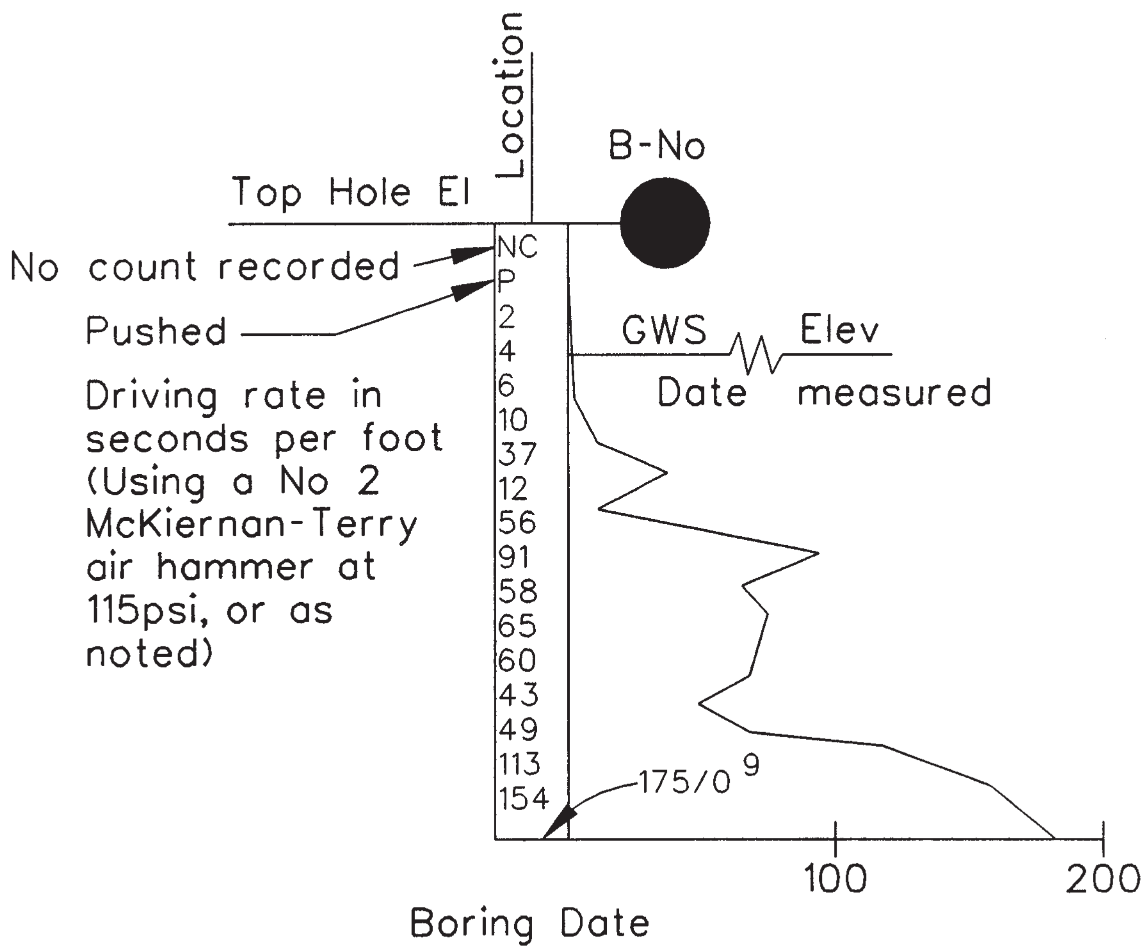
Classification of earth material as shown on this sheet is based upon field inspection and is not to be construed to imply mechanical analysis


2 1/4" CONE
PENETROMETER
SIZE
SAMPLE
BORING (DRY)
SIZE
ROTARY SAMPLE
BORING (WET)
SIZE
AUGER
BORING (DRY)
TEST PIT
SIZE
DIAMOND
CORE BORING
SIZE
JET BORING
ELECTRONIC CONE
PENETROMETER

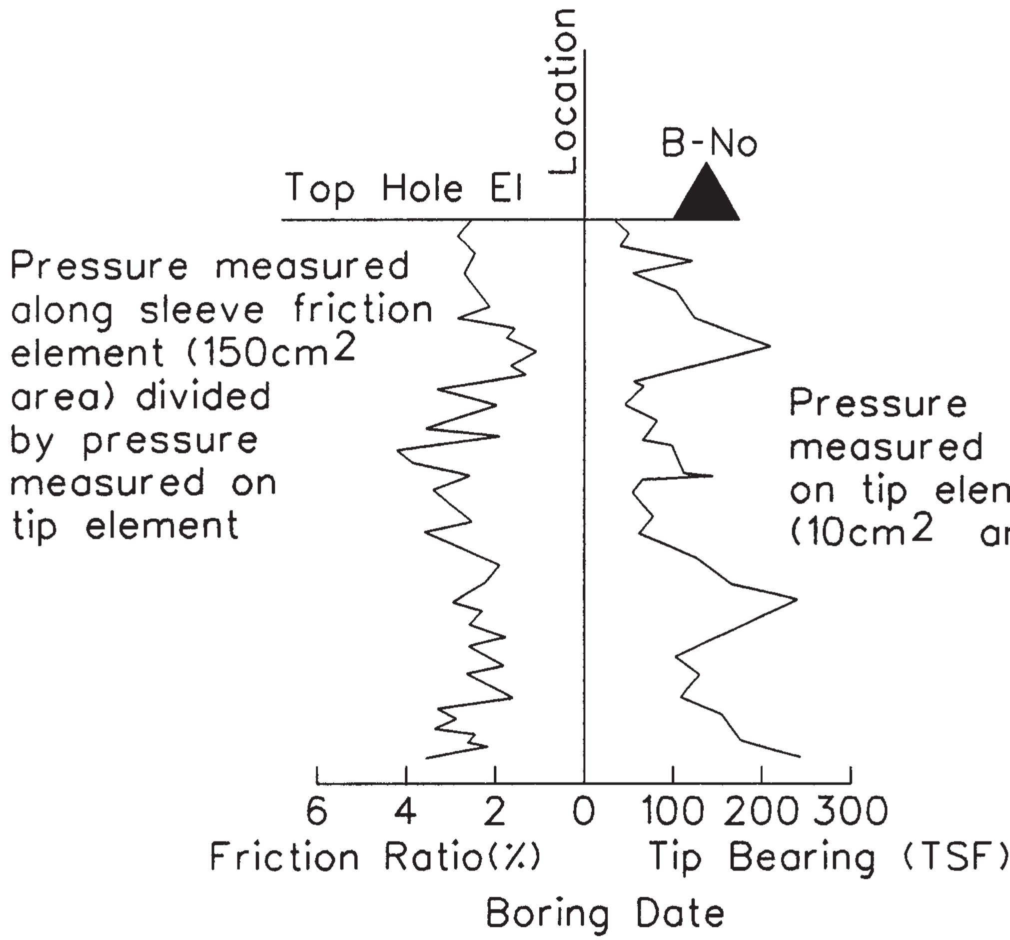


SAMPLE BORING (DRY)


Description of material
Unit weight (lb/cu ft)
% moisture
consolidation test
Elev
Date measured
GWS
Conformable material change
Estimated material change
Unconformable material change
B-No
3"
103
64
C
Location
Top Hole El
Casing driven
Size of Sampler
Penetration index (Using a 140 lb hammer with a 30" drop, or as noted)
2.4
35
1.4
Unconfined compressive strength (tons/sq ft)
400
VS
Shear strength (lb/sq ft)
Vane Shear
Boring Date
ROTARY SAMPLE BORING (WET)



2 1/4" CONE PENETRATION BORING



ELECTRONIC CONE PENETROMETER TEST

Cone Penetrometer dimensions and testing procedures are in accordance with ASTM standard D-3441-79, or as noted.

State of California Business, Transportation and Housing Agency

Memorandum

To : MR. M. W. HORN, Acting Chief
Office of Structure Design

Attention Mr. E. K. Thorkildsen
Design Section 6

Date : June 2, 1994

File No. : 05-SBt-156-7.3/R15.2
05-027101

San Benito River Bridge
Bridge No. 43-0044

From : **DEPARTMENT OF TRANSPORTATION** – 227-7206
Division of New Technology, Materials and Research
Office of Engineering Geology

Subject : Foundation Investigation

A foundation investigation was conducted for the San Benito River Bridge, Bridge No. 43-0044, by the Office of Engineering Geology . The San Benito River Bridge is part of the new alignment of Route 156, Hollister Bypass. The investigation included six 45.7 m (150-foot) deep mud rotary borings and seven 57 mm (2-1/4 inch) cone penetrometer borings drilled in November/December 1993. Also included are three mud rotary borings and one electronic cone penetrometer test performed in September/October 1992 by District 5. Additional borings (beyond the bridge site) are included in District 5 "Materials Information" (MI) package.

Geology

The general geology of the site is Cenozoic alluvial deposits of the San Benito River. The subsurface materials are interbedded clays, silts, sands, gravels and scattered small cobbles. The following list gives generalized descriptions and elevations of the soils at the San Benito River Bridge site. Please refer to the Log of Test Borings for better detail.

Generalized elevations	Generalized Soil Descriptions
71.6 m (235 ft) - 68.6 m (225 ft)	slightly compact to compact sand & gravel
68.6 m (225 ft) -57.9 m (190 ft)	soft to stiff silty clay, slightly compact to compact clayey silt and compact to dense sand
57.9 m (190 ft) - 45.7 m (150 ft)	compact to very dense sand and gravel with some small cobbles (up to 3-6 inch)
45.7 m (150 ft) -30.5 m (100 ft)	interbedded compact to hard clay and dense to very dense silt and sand
30.5 m (100 ft) - 24.4 m (80 ft)	very dense sand, silt and hard to very hard silty clay

Ground Water

Ground water was encountered in the San Benito River channel as shown on the Log of Test Borings. The highest groundwater level measured was elevation 66.8 m (219 ft) in B-2 (near Bent 4). No ground water was encountered at Abutment 1 which is located outside the active river channel. The ground water elevation and surface flow are extremely variable due to the hydrology of the river basin, the seasonal rainfall, and the water withdrawal by the local water district.

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June 2, 1994
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Bent 4 is located in the live channel of the San Benito River. Water was flowing in the channel in November/December 1993, 0.6-0.9 m (2-3 feet) deep at Bent 4. Surface water may need to be diverted during construction.

Scour Depth

The San Benito River is actively degrading, producing scour around existing bridges. Approximately one mile upstream from the proposed San Benito River Bridge site, Bridge No. 43-07 (along Highway 152), has a history of scour and embankment erosion problems. Three years after the bridge was built (1953), tetrahedron slope protection was necessary to protect the abutments. Beginning in 1978, man-made alterations to the river channel caused the river to degrade exposing the bent piles as much as 1.5 m (5 feet) below the pile cap (the City of Hollister made channel improvements upstream for the sewer treatment plant in 1978, and aggregate mining in the riverbed commenced downstream in 1989). Maintenance on the embankments and bents requires continuous addition of rip-rap and backfill.

Man-made alterations to the river will strongly influence the amount of scour and degradation of the channel. Aggregate mining will occur upstream and downstream of the San Benito River Bridge. Therefore, predicted scour depth elevations (due to mining) provided by Preliminary Investigations will be used for pile cut-off elevations. The Division of Structures, Preliminary Investigations Section, has predicted scour depth elevations to 56.7 m (186 ft) at the bent locations and 61.3 m (201 ft) at the abutments.

The historical scour depth elevation in the San Benito River channel, as determined from soil borings, extends to elevation 68.6 m (225 ft) at the channel edges and elevation 67.1 m (220 ft) in the active channel. The current design locates Abutment 1 24.4 m (80 ft) west of the channel edge with the bottom of pile cap elevation at 70.4 m (231 ft). Due to expected river alterations and subsequent channel erosion, the soil beneath Abutment 1 could be eroded, exposing the pile cap. Therefore, the bottom of pile cap at Abutment 1 should be constructed below the historical scour depth elevation of 68.6 m (225 ft). Rock Slope Protection could protect the pile cap, but future maintenance may be required. Abutment 6 should be constructed below historical scour depth elevation 67.1 m (220 ft). Abutment 6 is located in the active river flood plain with the bottom of pile cap placed at elevation 65.5 m (215 ft).

Rock Slope Protection (RSP) shall be placed at both Abutments 1 and 6. At Abutment 6, RSP shall extend to elevation 64.0 m (210 ft), 1.5 m (5 ft) below the bottom of pile cap elevation. At Abutment 1, RSP shall extend to elevation 67.1 m (220 ft), 3.4 m (11 ft) below the proposed bottom of pile cap elevation, and 1.5 m (5 ft) below the historical scour depth elevation at channel edge.

Fault and Seismic Data

The site is located near two major active faults. The nearest known potentially active fault is the Sargent fault (M=6.75). The Sargent fault is located 1.9 km (1.2 miles) northwest of the site. The Calaveras fault (M=7.5) is located 3.1 km (1.9 miles) to the east. The predicted maximum credible horizontal bedrock acceleration is 0.7g from the Calaveras fault. Use Design Force Coefficient Curve " >47.7" (>150).

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June 2, 1994
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Settlement Periods

District 5 Materials Laboratory has analyzed the foundation soil settlements at the approach embankments for the San Benito River Bridge. Abutment 1 is anticipated to have 17.8 mm (0.7 inch) of long-term settlement requiring a 30-day fill delay prior to pile installation. Abutment 6 is not anticipated to have long-term settlement and no fill delay is required. Please contact Ron Richman, District 5 DME for further details.

Corrosion

Preliminary test results show that the San Benito River site is a non-corrosive environment.

Foundation Recommendations

Cast-In-Drilled-Hole (CIDH) piles using slurry displacement are recommended for support of the structure shown on the "General Plan" dated 12/14/93. Specified pile tip elevations for 3.05 m (120-inch) and 0.91 m (36-inch) diameter CIDH piles are shown in Tables 1 and 2. The design loads were supplied by Structure Design and are noted in the tables.

Due to future aggregate mining in the river, the pile cut-off elevations correspond to the predicted scour elevations as determined by Preliminary Investigations (report dated 11/23/93). The piles are considered to be unsupported by soil above the predicted scour elevations of 56.7 m (186 ft) at the bent supports and 61.3 m (201 ft) at the abutments.

The bent support design loads, given in Table 1, do not include the pile weight [1673 kN (188 tons)] from the column bottom to the cut-off elevation [elevation 66.4 m (218 ft) to 56.7 m (186 ft)]. Therefore, the specified pile tip elevations for Bents 2, 3, 4, and 5 were determined by adding 1673 kN (188 tons) to the design load.

Table 1

3.05 m (120-inch) CIDH Pile Data (2)
Bent Supports

Location	Diameter	Design Loading (1) (Service Load)	Pile Cut-off Elevation (3)(4)	Specified Tip Elevation
Bent 2	3.05 m (120-inch)	15040 kN (1690 tons)	56.7 m (186 ft)	25.3 m (83 ft)
Bent 3	3.05 m (120-inch)	15580 kN (1750 tons)	56.7 m (186 ft)	26.8 m (88 ft)
Bent 4	3.05 m (120-inch)	15580 kN (1750 tons)	56.7 m (186 ft)	25.6 m (84 ft)
Bent 5	3.05 m (120-inch)	15040 kN (1690 tons)	56.7 m (186 ft)	26.5 m (87 ft)

(1) The ultimate compressive capacity is 2x design load.

(2) Method of support is friction and end bearing.

(3) CIDH piles are considered unsupported by the soil above the cut-off elevation.

(4) No casing is to remain below the cut-off elevation

Mr. M. W. Horn
June 2, 1994
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Table 2

0.91 m (36-inch) CIDH Pile Data (2)
Abutment Supports

Location	Diameter	Design Loading (Service Load) (1)	Pile Cut-off Elevation (4)	Specified Tip Elevation (3)
Abutment 1 (5)	0.91 m (36-inch)	1340 kN (150 tons)	61.3 m (201 ft)	51.8 m (170 ft)
Abutment 6 (6)	0.91 m (36-inch)	1340 kN (150 tons)	61.3 m (201 ft)	51.8 m (170 ft)

(1) The ultimate compressive capacity is 2x design load.

(2) Method of support is skin friction.

(3) Battered CIDH piles shall not be used.

(4) CIDH piles are considered unsupported by the soil above the cut-off/scour depth elevation.

(5) 30-day fill delay required for Abutment 1. See District 5 Materials report.

(6) No fill delay required for Abutment 6.

Constructability

Slurry displacement is recommended for constructing the CIDH piles at all support locations. Caving and loss of slurry mud may be a problem, especially in the sand and gravel layer between elevation 57.9 m and 45.7 m (190-150 ft – generalized elevations – refer to Log of Test Borings for detailed elevations). Jetting may create large voids especially in the sand layers; therefore, jetting should be avoided. Due to shallow tip elevations and low ground water elevations at Abutments 1 and 6, slurry displacement may not be necessary. The tip elevation at Abutment 6 extends 1.5 m (5 feet) into ground water as measured on November 30, 1993 (ground water could be higher during construction).

If temporary casing is used during construction, **all casing below the scour depth/cut-off elevation shall be removed**. The piles will not achieve design load if casing remains below the scour depth.

LAUREL S. JENSEN
Associate Engineering Geologist

R. W. FOX, C.E.G. No. 78
Senior Engineering Geologist

cc: Preliminary Report
R.E. Pending File
DBarlow - Specs & Estimates
District 5 (2)
ELeivas - OEG
Engr. Geology (4)